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SOME COMPARISONS BETWEEN NUCLEI OF NERVE CELLS

By William A. Hilton

Nuclei were compared from a large number of animals, chiefly invertebrates. In this short paper nuclei alone are drawn. No special method has been applied at this time. In all cases strong fixing reagents and strong stains were used, such as Flemming's fluid or mercuric cloride. The stain used was hematoxylin in most cases. Slight differences which one or another reagent gives will not be entered into at present. The figures were made from preparations which seemed to be typical cells for the animal. In the methods used no great differences were seen in the appearances of the nuclei except that by some methods they stained more intensely.

The study is particularly directed towards a comparison of the distribution of the basichromatin in the nuclei. All drawings are at the same scale and drawn with a camera lucida with the best oil immersion objective available.

Many of us appreciate the advances which Biology has made through the aid of chemical interpretations and physical and chemical explanations. Some are inclined to belittle pure morphological studies, but it seems in many cases that we have to come back to the purely anatomical and morphological investigations in order to advance. Great attention has been given to the dividing period of cell activities, but are not the periods between division more important in many respects? Is it not probable that this is the time when the nature of the cell is determined? Evidence has gradually been accumulating to show that the nucleus and the materials within it are closely related to the cell body and its activities.

The nucleus is probably not concerned with conduction or the special activities of the neurone, although it may have to do with nutrition. Even in Protozoa Verworn '88 (1), denies the nucleus being the seat of any psychic activity as expressed by motion. The nucleus seems to have nothing to do directly with irritability; fragments without nuclei respond as readily to stimuli as other parts. That the nucleus controls or conditions the character of the cell body seems true to some degree, but just how much, opinions differ. In those cells which retain their power to divide the chromatin content remains large, in those which differentiate, this chromatin falls proportionately, but in some cells it may be restored once more when certain stimuli or special nutrition prepares them for division again. Nerve cells and some others do not as a rule divide after their mature life is reached, and in these the chromatin content is especially reduced. E. Rohde '11 (2) calls attention to the reduction of chromatin in other than germ cells and compares the loss through polar body formation to the loss in nerve cells, yolk cells and in the extreme condition in the red blood cells of mammals.

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(1) Zeit. f. wiss. Zool. llvi.

Although nerve cells do not divide they may give out growths during this period as shown by G. Marinesco and J. Minera '14 (3), who studied a culture of spinal ganglion cells *in vitro*. The connective tissue cells did grow by multiplication, but the nerve cells did not divide although they gave out processes. From other evidence it seems possible also that in the adult central nervous system there may be growth or change of position of fibers to make new connections.

M. Muhlmann '11 (4), has studied the structure of nerve cells at different ages in mammals. He finds at first a large amount of chromatin in the nucleus, later it became less, some goes to form a sort of nucleolus. The tigroid substance of the cell body gradually increases. Later Muhlmann '14 (5) studied the composition of Nissl's granules and found that they have a nuclein content along with globulin, but the nuclein of Nissl's granules differs from that of nuclei because the tigroid substance is soluable in alkalis and the chromatin of the nucleus is not. Just what relation the lost chromatin of nerve cells bears to the cytoplasm remains to be clearly determined, but that there is a relation seems clear from the work of many.

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(2) Zeit. f. wiss. Zool. xcviii.

(3) Anat. anz. 1914.

(4) Arch. mic. Anat. lxxvii.

(5) Arch. mic. Anat. llvi.

H. Stauffacher '10 (6) studied the nuclear structure in animal and plant cells and found the oxychromatic matrix substance of the nucleolus connected by internal nuclear bridges with the oxychromatin of the nucleus and that, with the oxychromatin of the cytoplasm. Basichromatin always has an oxychromatin foundation. Nucleoli arise from oxychromatin and pass to the nucleus and from there into the cell substance. Nuclein has to do with growth and metabolism. He does not believe in a nuclear membrane. The drawings and photographs of Stauffacher look very convincing. I have found similar conditions in some germ cells. J. Schaxel '10 (7) speaks of the regulative emmission of chromatin to the cell from the nucleus. W. Knoll '10 (8) has studied the leucytes in bone marrow. Nuclear bridges connect contractile parts of the nucleus with contractile parts of the cytoplasm. There are many other papers with similar evidence which suggest either a close chemical interrelationship or definite organic connection between cytoplasm and nucleus.

That nuclei may receive again from the cytoplasm, or that the cell body aids the nucleus in the growth of its chromatin seems clear from the recent work of V. Danchakoff '16 (9). "Accumulations of basophilic substance are found in the cytoplasm * * *. The small achromatic nucleus of the mature egg both after fertilization and at the beginning of parthenogenesis seem to exert a strong attraction on the basophilic accumulations found in the cytoplasm. This substance is soon displaced and localized around the nucleus. At the same time a radiation around the nucleus is perceptible, which is apparently the expression of the flowing of the basophilic substance towards the nucleus * * *. The close relation between the true chromatin bodies within the nucleus and the basophilic chromatic substance in the cytoplasm is easily traced."

In a study of a large number of nerve nuclei such as shown in figs. 1 to 17 and fig. 22, it is found that in most nuclei there is but a scanty distribution of nuclear material which is proportionately less in the larger nuclei of cells that have very large cell bodies. In most cells there is a well-marked, usually clear nucleolus. In many there are many fine strands of linin visible, usually radiating from the center of the nucleus. The smallest animals have the smallest cells and these have the smallest nuclei. Very often the smallest nuclei do not look much like those of nerve cells, such as those of Podura (fig. 13) and Aphorura (fig. 12), seem more like neuroblasts or young cells although their chromatin content is small. In the larger animals there was considerable variation noted in cells from the same animal, such as in L. grandis, fig. 6, Trantula fig. 10, Corydilis, fig. 16.

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(6) Zeit. f. wiss. Zool. xcv.

(7) Verh. viii Intnat. Zool. Kong. zu Graz. 1910.

(8) Zeit. wiss. Zool. xcv.

(9) Jour. morph. vol. xxvii, no. 3.

In all the preparations probably the more granular nuclei are those from neuroblasts and a few of the clear nuclei may be of neurogolia cells. In the nerve nuclei of a young salamander Desmognathus, fig. 22, the chromatin is very abundant and the cells with such nuclei are capable of active multiplication. In figs. 23 and 24 from muscle and connective tissue cells, the scanty chromatin would be insufficient for immediate division. Figs. 18 to 21 are from another salamander, a larval Amblystoma. Fig. 18 from the retina might soon have more chromatin and divide, one of the epithelial cell nuclei of fig. 19 could soon divide and fig. 20 from the blood has a mass of chromatin and the muscle nucleus of fig. 21, is not near division.

No more than a general idea of the distribution of the chromatin in the nuclei of nerve cells can be learned from these figures. A general type of nucleus shows fairly well in all but the smallest and youngest specimens. The type is that usually recognized for the nerve cells of vertebrates, that is a large rather clear nucleus with a nucleolus which is also rather clear. There seems to be nothing especially peculiar to nerve cell nuclei which would prevent the cells of the adult from receiving a stimulus of some sort to increase the chromatin of the nucleus and allow further division of the cells.

Whether the arrangement of the chromatin means anything or not in determining the nature of the cells cannot be told from these preparations, but I do not doubt that this as well as any particular or peculiar arrangement of the nuclear parts may be of importance at one time or another in determining the nature of cytoplasmic manifestations.

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EXPLANATION OF FIGURES

All figures drawn by the aid of a camera lucida by means of an oil immersion objective. All enlarged eight hundred diameters.

Fig. 1. Nerve nuclei from the starfish, Orthasterias.

Fig. 2. Nerve nuclei from the starfish, Piaster capitatus.

Fig. 3. Nerve nuclei from the crustacean, Nebalia.

Fig. 4. Nerve nuclei from the crustacean isopod, Lygida.

Fig. 5. Nerve nuclei from the crustacean isopod, Lygida 4mm. long young.

Fig. 6. Nerve nuclei from the crustacean decapod, Loxorhynchus grandis.

Fig. 7. Nerve nuclei from the pycnogonid, Lecythorhynchus marginatus.

Fig. 8. Nerve nuclei from the whip-scorpion, Tythreus pentapeltis.

Fig. 9. Nerve nuclei from the pseudoscorpion, Chelifer.

Fig. 10. Nerve nuclei from the tarantula spider.

Fig. 11. Nerve nuclei from the thysanuran insect, Campodea.

Fig. 12. Nerve nuclei from the collembolan insect, Aphorura.

Fig. 13. Nerve nuclei from the collembolan insect, Podura.

Fig. 14. Nerve nuclei from the collembolan insect, Sminthurus.

Fig. 15. Nerve nuclei from the thysanuran insect, Machilis.

Fig. 16. Nerve nuclei from the larval insect, Corydalis.

Fig. 17. Nerve nuclei from the ascidian, Tunica.

Fig. 18. Nucleus from one of the retinal cells of the larval salamander Amblystoma 15 mm. long.

Fig. 19. Nuclei from epithelial cells of larval Amblystoma, 15 mm. long.

Fig. 20. Nucleus from the blood of a 15 mm. larval Amblystoma.

Fig. 21. Nucleus from the muscle of a 15 mm. larval Amblystoma.

Fig. 22. Nuclei from brain of a young salamander, Desmognathus.

Fig. 23. Nucleus from striated muscle from young Desmognathus.

Fig. 24. Nucleus from connective tissue from young Desmognathus.

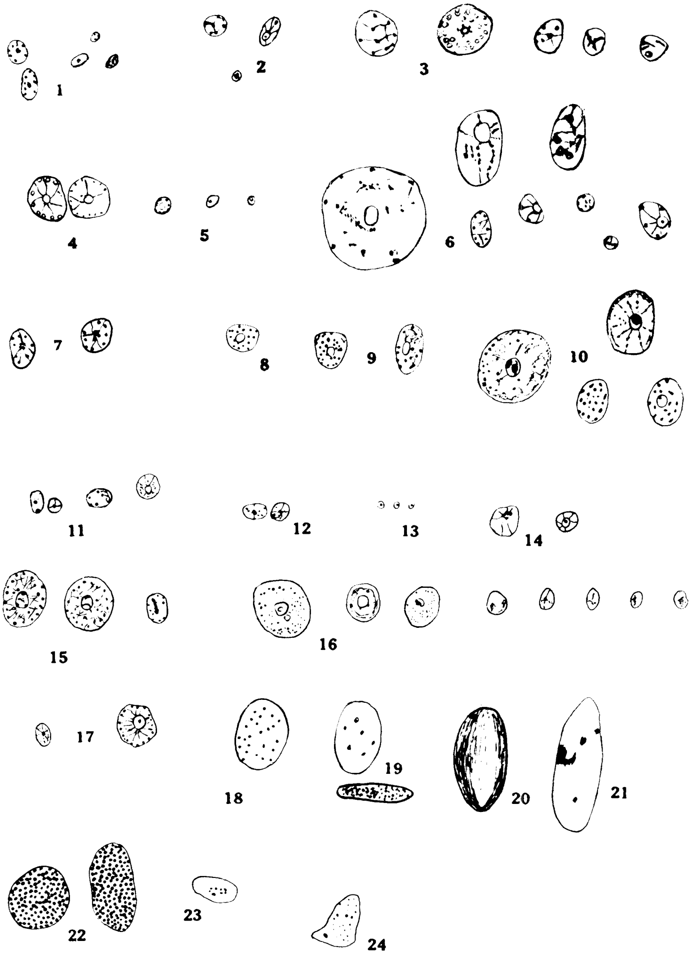

Plate XVI